International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)
ISSN(P): 2249-6866; ISSN(E): 2249-7978
Vol. 5, Issue 1, Feb 2015, 75-82

GIS BASED SIMPLISTIC NOISE PREDICTION MODEL FOR URBAN AREAS

DIVYAKANT TAHLYAN & ANURAG OHRI

Department of Civil Engineering, Indian Institute of Technology (BHU), Varanasi, Uttar Pradesh, India

ABSTRACT

In the rapidly urbanizing country like India, overcrowded roads are leading to growing concerns over noise pollution. To take proper decisions and to analyze the environmental impact of this urban noise pollution, it is important to know the variation of noise levels throughout the study area. Unlike usual stationary sources of noise, traffic noise has a mobile source. The combined effect of these mobile as well as stationary sources can be visualized by considering these mobile sources as equivalent multi-point stationary sources.

In the present study conducted in an urban city of India named Chandigarh, Noise Level Variation maps were prepared by considering the combined effect of mobile as well as stationary sources of noise. Equivalent Continuous Sound Level (L_{eq}) data for day (0600 hrs to 2200 hrs) as well as night (2200 hrs to 0600 hrs) time, from 261 noise monitoring stations (including data from link roads) was used in the study. The collected data was used in the GIS environment, which is the fastest method available to deal with large spatial data and to produce the most reliable results. This multi-point equivalence model of mobile sources was validated by randomly selecting 23 sample points from the available data points of known noise levels. The results obtained revealed the trends in noise variations throughout the city in the form of noise maps.

KEYWORDS: Geographic Information System, Noise Map, Noise Pollution, Stationary And Mobile Sources, Equivalent Multi-Point Stationary Sources

INTRODUCTION

For a growing economy like India, where the rate of urbanization in the cities is quite high, traffic noise is a significant source of noise pollution. It is one of the most immediate and identifiable environmental problems linked with rapid industrialization, urbanization and population growth (**Alam 2011**). By and large, high vulnerability to noise level can cause feeling of annoyance and irritation, damage to auditory mechanisms, a number of health related effects like physiological disorders, psychological disorders, disturbances of everyday actions and performances, hypertensions and ischaemic heart diseases (**Canter 1996**). Since, increasing ambient noise levels in public places from various sources, industrial activity, construction activity, generator sets, loud speakers, public address systems, music systems, vehicular horns and other mechanical devices have deleterious effects on human health and the psychological well being of the people, it is considered necessary to regulate and control noise producing and generating sources with the objective of maintaining the ambient air quality standards in respect of noise **(MoEF 2000)**. In India, Noise Pollution (Regulation and Control) Rules, 2000 limits the Ambient Air Quality Standards in respect of Noise as given in **Table 1.**

Table 1: Ambient Air Quality Standards in Respect of Noise in India

Category of Area/Zone	Limits in dB(A) L_{eq}	
	Day Time	Night Time
Industrial Zone	75	70

Table 1: Contd.,		
Commercial Zone	65	55
Residential Zone	55	45
Silence Zone	50	40

To assess the environmental impact of noise pollution, it is important to have a clear knowledge about variation of noise levels throughout the study area. Since it is not practicable to assess noise levels at each and every stage, noise prediction models are applied to predict noise levels in the study area.

There are many noise prediction models like FHWA highway traffic noise prediction model **(FHWA 1978)**, CoRTN model **(Anonnymous 1975)**, RLS 90 model etc **(Suksaard et al. 1999)**, **(Steele 2001)**, **(Bendtsen 1999)** to predict the noise levels. A common criticism of these models is that all these prediction models do not provide a format where noise levels can be easily visualized in one or the other form **(Sharma et al. 2009)**.

Geographic Information System (GIS) offers a reliable facility to visualize such phenomenon through its spatial analysis and modeling tools. GIS can be easily applied to utilize and manipulate large spatial data and develop noise maps based upon the data collected from noise monitoring stations. These maps can be further used to visualize noise levels and study its impact on a desired area. In the present study conducted in an urban city of India named Chandigarh, Noise Level Variation maps were prepared by considering the combined effect of mobile as well as stationary sources of noise. Equivalent Continuous Sound Level (L_{eq}) data for day (0600 hrs to 2200 hrs) as well as night (2200 hrs to 0600 hrs) time, from 261 noise monitoring stations (including link roads) was used in the study. The collected data was used in the GIS environment, which is the fastest method available to deal with large spatial data and to produce the most reliable results. This multi-point equivalence model of mobile sources was validated by randomly selecting 23 points of known noise level from the available sample set. The obtained noise variation trends throughout the city can be used for further planning and policy making by government agencies and Municipal Corporation.

MATERIALS AND METHODS

Study Area

Chandigarh is located at the foothills of the Shivaliks about 250 kms North of New Delhi. It lies between north latitudes 30º 40’0” to 30º 46’0” and east longitudes 76º 42’0” to 76º 51’0” and falls in Survey of India topo-sheet no. 53B/14. Punjab state borders the Union Territory Chandigarh in the south and south-western sides and Haryana state on eastern side. Chandigarh has an area of 114 square kilometers out of which 36 square kilometers is rural and remaining 78 square kilometers, is urban. As per Census of India 2011, Chandigarh has a population of 1.054 million, an increase of 153 thousand from 901 thousand in 2001 census. The city has a population density of 9,252 people/km^2, which makes it the second most densely populated union territory in the country. Being the joint capital of Punjab and Haryana, the city is being used as an administrative center by both the states. For a population less than 1.1 million, there are about 0.870 million registered vehicles in the city. One singular feature in the layout of Chandigarh is its roads, classified in conformity with their uses. An integrated system of seven roads was designed to ensure efficient traffic circulation. City’s architect Le’Corbusier referred to these as the 7’ Vs. The city’s vertical roads run northeast/ southwest (The ‘Paths’) and the horizontal roads run north-east/South-east (The ‘Margs’) (Figure 1). They intersect at right angles, forming a grid of network for movement. This arrangement of road-use leads to a remarkable hierarchy of movement, which also ensures that the residential areas are segregated from the noise and pollution of traffic.

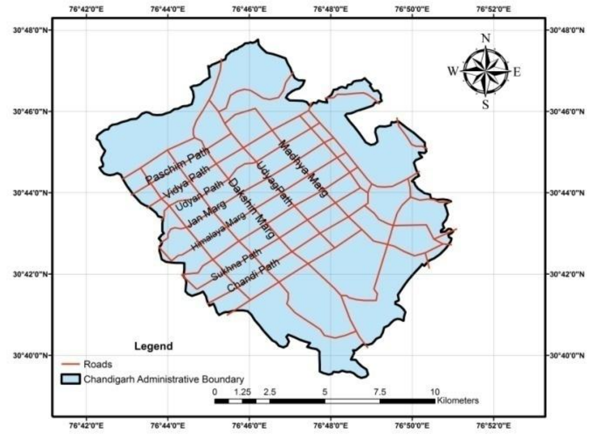

Figure 1: Major Link Roads of the City

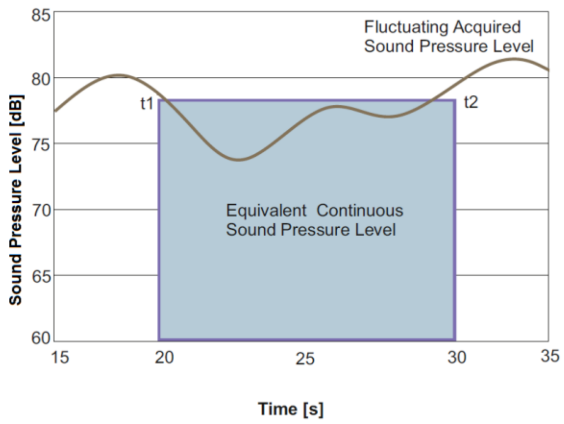

Figure 2: Graph Showing Calculation of Leq Sound Pressure Level

METHODOLOGY

Noise level data from 261 noise monitoring stations was used to evaluate noise levels throughout the city. A sound level meter was used to determine the noise level. A sound level meter measures the sound pressure level in dB (A) i.e. decibels in A weighted scale. The sound pressure level or sound level measured in decibel (dB) is a logarithmic measure of the effective sound pressure of a sound relative to a standard reference value. The dB (A) L_{eq} denotes the time weighted average of the sound pressure level in decibels on scale 'A' which is relatable to human hearing **(Figure 2)**. The L_{eq} is calculated using equation (1):

$$\text{Leq} = \mathbf{10log}\left[\frac{1}{t1-t2}\int_{t_1}^{t_2}\frac{p_A^2}{p_0^2}\,dt\right] \tag{1}$$

- L_{eq} = equivalent continuous sound pressure level [dB]
- p_0 = reference pressure level = 20μPa
- p_A= acquired sound pressure in Pa
- t_1 = start time for measurement
- t_2 = end time for measurement

Steps involved in making noise variation maps using GIS are shown in **Fig**ure **3**. The methodology works in three phases.

Phase 1 involves collection of noise level data from 261 noise monitoring stations. Out of these 261 stations, 167 stations measure noise from city sectors and rest 94 measure noise from link roads. Leq noise level data and maximum noise level data for day (0600hrs to 2200hrs) and night (2200hrs to 0600) time was used in the study.

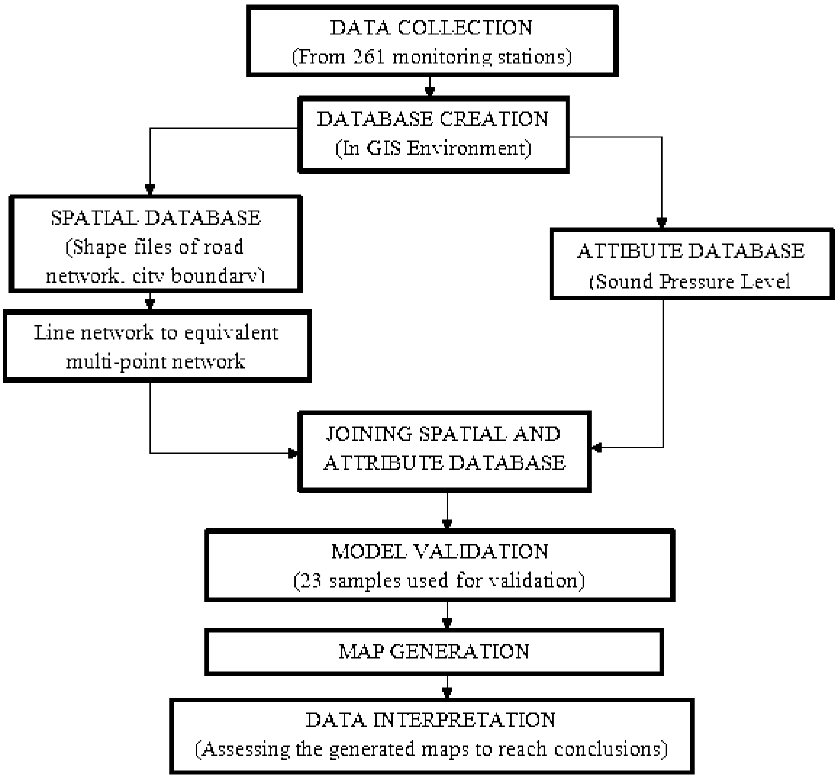

Figure 3: Flowchart Showing the Methodology Adopted

Phase 2 involves creation of geo-database in GIS environment. Geo-database includes spatial as well as attribute database. Spatial database includes shape-files of link roads, noise monitoring points and administrative boundary extents of the city. The link road shape-files were converted to an equivalent point file as shown in **Figure 4.** The attribute database includes noise data collected from 261 noise monitoring stations. These spatial and attribute databases were joined to each other. Every point source of noise was connected to its corresponding noise level. However, in case of equivalent point sources, all points on a link road were given equal value per its corresponding noise monitoring station.

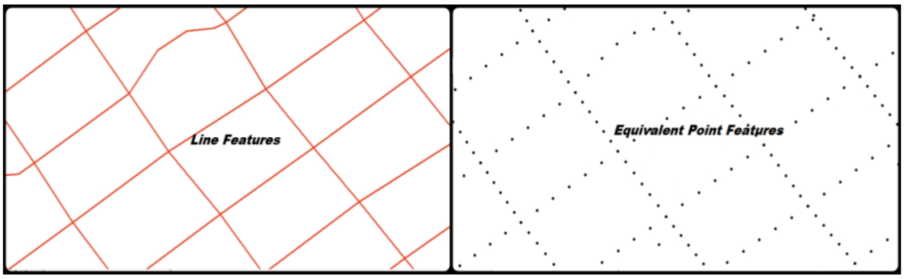

Figure 4: Line Source to Equivalent Stationary Feature

Phase 3 includes model validation and map generation using inverse distance weight (IDW) interpolation technique. Out of the available sample points, 23 sample points were randomly selected for model validation **(Figure 5)**. Using points other than the selected for validation, Leq and maximum noise level variation maps for day and night time were prepared with interpolation technique. A graphical comparison of the predicted and observed noise levels is also shown in **Figure 6 (a), (b), (c) and (d)**.

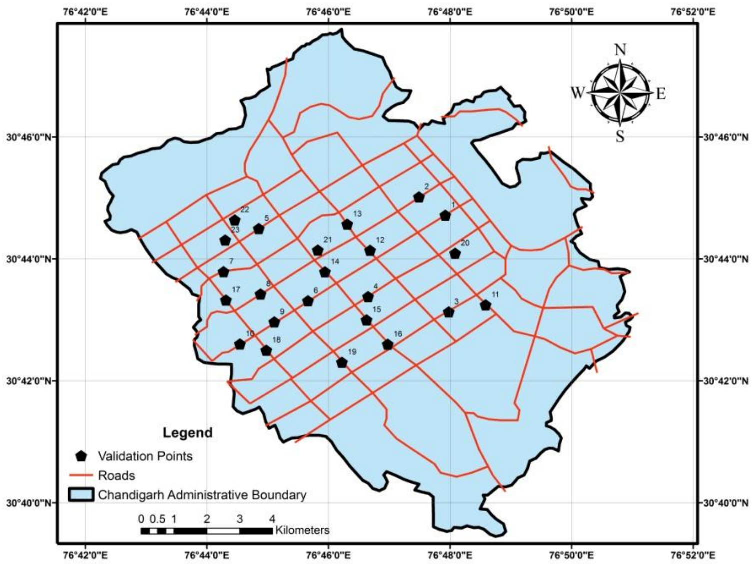

Figure 5: Points Used from Model Validation

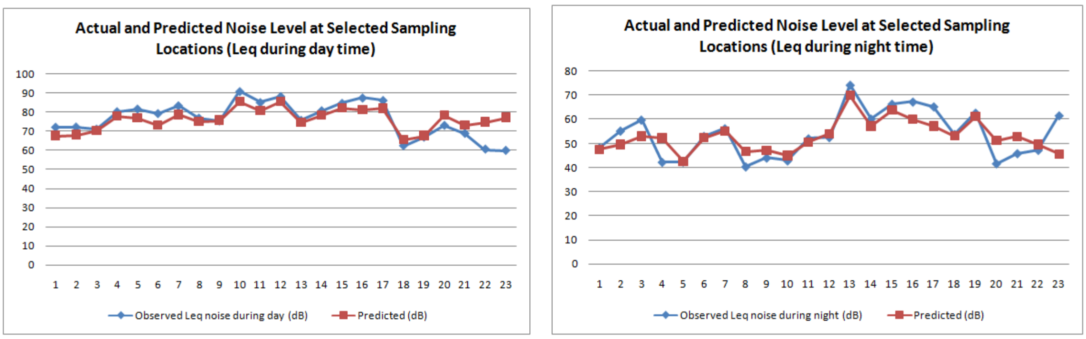

Figure 6: Actual and Predicted Noise Level at Selected Locations (a) L_{eq} during Day Time; (b) L_{eq} during Night Time

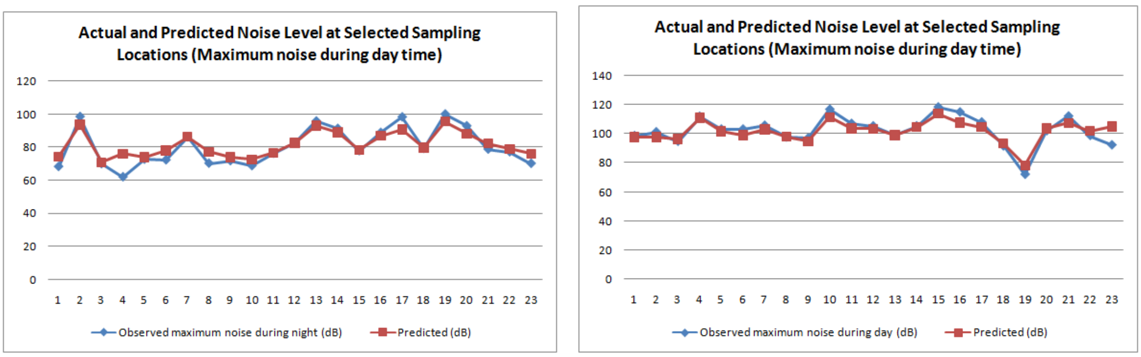

Figure 7: Actual and Predicted Noise Level at Selected Locations (c) Maximum Noise During Day Time; (d) Maximum Noise During Night Time

RESULTS AND DISSCUSSIONS

The GIS based multi-point equivalence model adopted for noise prediction revealed the trends in the noise levels throughout the city. The distribution of L_{eq} and maximum noise levels in the city for day (0600hrs to 2200hrs) and night (2200hrs to 0600hrs) is given the figure 8 and 9 respectively as per ambient air quality standards in India (Table 1). Prepared noise maps reveal the trends in noise levels in the city.

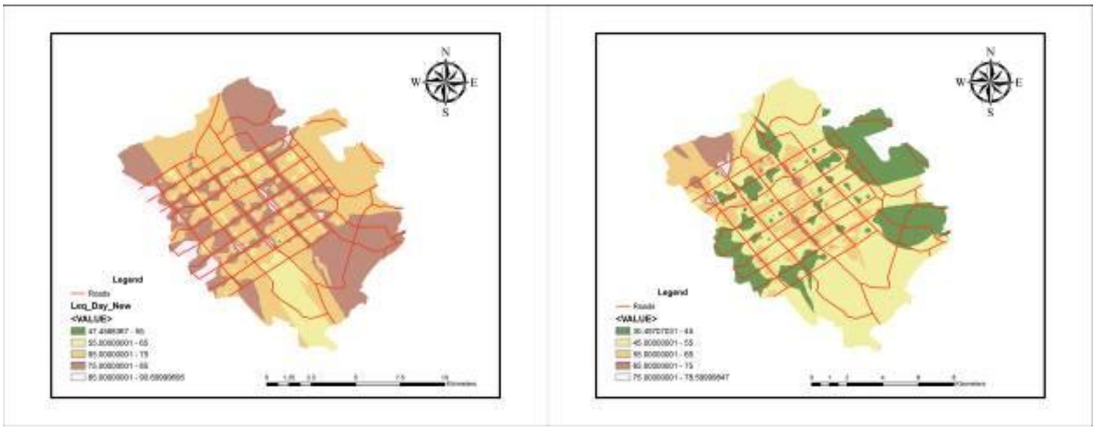

Figure 8: L_{eq} Sound Pressure Level During Day (Left) and Night (Right)

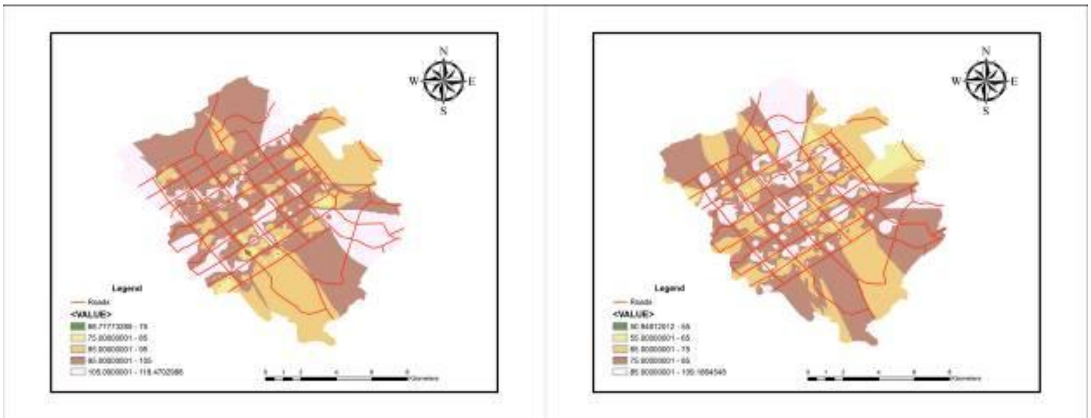

Figure 9: Maximum Sound Pressure Level During Day (Left) and Night (Right)

Figure 10 shows that major part of the city lies in 65-85 (dB) L_{eq} range during day time (0600hrs to 2200hrs) and 45-55 (dB) L_{eq} range during night (2200hrs to 0600hrs) time. However, **figure 11** show that the maximum noise levels for major part of the city lies in 95-105 (dB) range during day (0600hrs to 2200hrs) and 65-85 (dB) range during night (2200hrs to 0600hrs)time. .

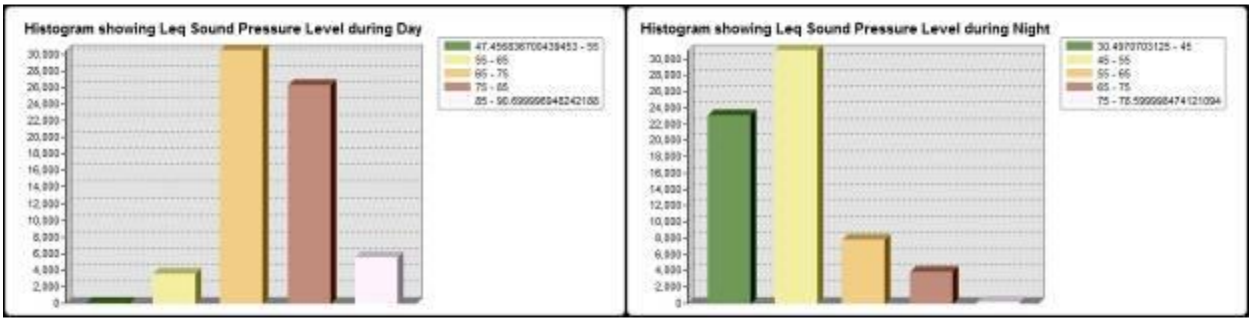

Figure 10: Histogram Showing L_{eq} Sound Pressure Level During Day (Left) and Night (Right)

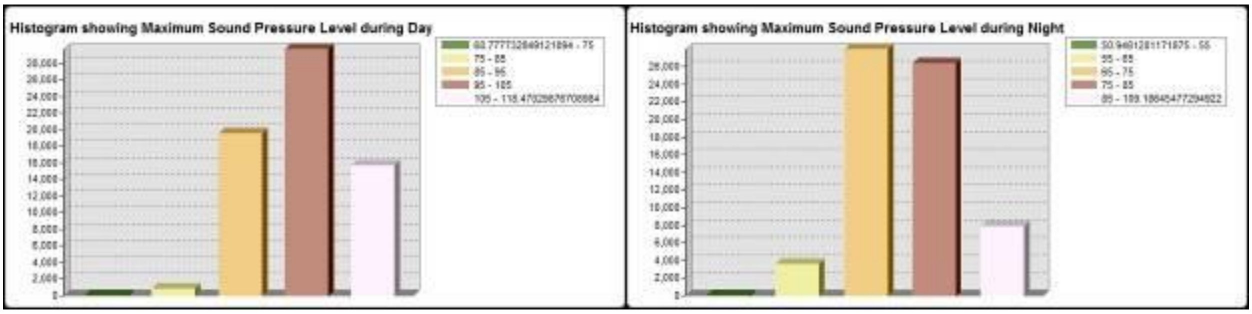

Figure 11: Histogram Showing Maximum Sound Pressure Level During Day (Left) and Night (Right)

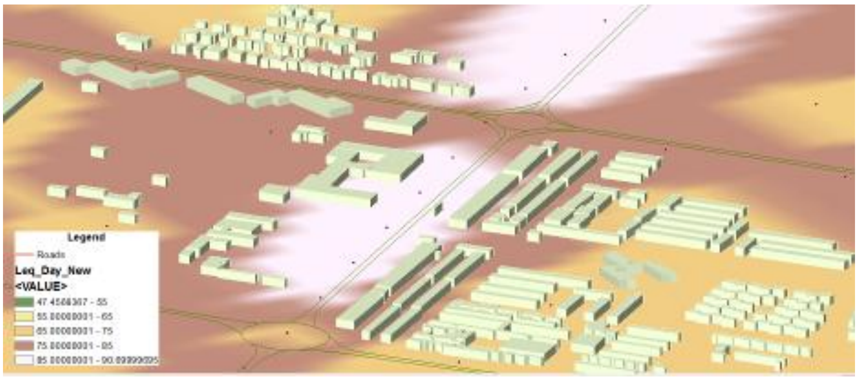

Figure 12: 3D View of a Part of City

Figure 12 shows L_{eq} sound pressure level map overlapped with the existing buildings near Udyog Path (ISBT Sector 17). Such overlapping can help in the easy visualization of noise trends and its effect on the buildings and people. The correlation coefficients between observed and predicted values of noise for L_{eq} Noise Levels for day and night time are 0.75 and 0.80 respectively. Also, the correlation coefficient between observed and predicted values of noise for maximum noise levels for day and night time are 0.95 and 0.92 respectively. The correlation coefficients show that the multi-point equivalence model for line sources of noise can be logically utilized to predict noise in the region.

CONCLUSIONS

Noise pollution is of growing concerns these days due to its immediate effect on people. This GIS based noise prediction model is handy as well as useful for better visualization of noise pollution in the form of maps, which otherwise is difficult to visualize. A better knowledge of the noise variation in the study region can effectively help in planning and design of green belts, noise barriers etc. which will eventually reduce the noise levels by a substantial amount.

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